NC STATE UNIVERSITY

Choices for Communities:

Wastewater Management Options for Rural Areas

WASTE MANAGEMENT PROGRAMS

COLLEGE OF AGRICULTURE & LIFE SCIENCES

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Wastewater Management Options for Rural Areas

Executive Summary

There's great news for rural communities in North Carolina faced with the challenge of developing wastewater management infrastructure. Today more options for wastewater management exist than ever before, and these options provide rural communities with environmental protection, needed flexibility to plan for future economic growth and lower installation costs than traditional centralized wastewater management systems.

In fact, in a 1997 report to the U.S. Congress, the Environmental Protection Agency (EPA) found that the "decentralized approach" to wastewater management favors rural communities and frequently will be more cost-effective than centralized sewering.

The combined use of conventional septic systems, advanced designs of on-site systems and cluster or other land-based systems to serve a community's wastewater management needs has been termed "decentralized wastewater treatment." According to the EPA's study findings, decentralized systems:

- Protect public health and the environment
- Are appropriate for low density communities
- Are appropriate for varying site conditions
- Provide additional benefits for ecologically sensitive areas, and
- Can provide significant cost savings while recharging local aquifers and providing other water reuse opportunities close to the points of wastewater generation.

Many rural communities in North Carolina lack a wastewater management system that can effectively protect public health, environmental quality, accom-modate future housing needs and facilitate growth. Decentralized wastewater treatment should be at the top of their list. However, North Carolina does not have at this time a comprehensive, statewide strategy that provides for the cost-effective treatment of municipal wastewater in rural areas.

History, Not Technology Favors Centralized Approach

Thanks to major federal funding during the 1970s and 1980s, most urban communities across North Carolina installed centralized wastewater systems to meet their citizens' needs. The federal money, combined with the failure of communities to adequately maintain traditional septic systems, provided justification for construction of sewers and a wastewater treatment plant. Usually, larger communities were favored over smaller communities to receive the majority of the federal funds.

During the '70s and '80s, most rural N.C. communities considered only two options to meet their wastewater management needs:

- Continue using poorly maintained traditional septic systems, or
- Install an extensive pipe network that collects wastewater to a centralized, highly maintained wastewater treatment plant.

These centralized systems have been termed the "big pipe" approach. They involve installing an extensive network of large sewer pipes throughout a community to collect wastewater and bring it to a central treatment plant, followed by disposal in a stream or body of water.

Today, however, major federal funding for wastewater management projects has been eliminated, and N.C. communities must bear the full cost of installation and operation and maintenance. The price tag to construct a centralized sewerage system has become prohibitive for less densely developed rural communities. And, increasing environmental requirements pose significant challenges for wastewater systems that discharge treated wastewater into surface waters such as rivers, streams and coastal waters.

Historically, wastewater treatment has been viewed as a disposal process, but today emphasis is on reuse and recycling.

Decentralized Options Abound

Today, there are multiple alternatives to centralized sewering. Conventional septic systems are dependable options where soil conditions are favorable and the systems are properly maintained. Advanced on-site systems (sand filters, peat filters, pressure distribution systems, drip-irrigation systems, disinfection systems) and community lagoon/spray irrigation systems can be used over a much broader range of site and soil conditions than the conventional septic systems. Cluster systems use small collection networks to bring wastewater from a limited number of houses (usually 5 to 100) to a common treatment and disposal area. Cluster systems use small-diameter gravity sewers and pressure sewer systems that are less expensive to install than the large pipes used in the centralized approach.

While these land-based, alternative wastewater systems are recognized as viable options, the treatment strategies are relatively new or not often recommended by some in the private sector. And in times past, these treatment techniques were not considered to be mainstream options that communities could depend on.

Yet, land-based systems have been judged to be the most cost-effective and environmentally sound wastewater treatment options for rural communities, now and in the future. Because these systems pose minimal environmental impacts on streams and rivers, the regulatory community requires assessment of land-based alternatives. Land-based systems require extensive planning and stepwise implementation depending on the area to be served.

Management, Maintenance and Inspections Are Key

The success of the decentralized approach depends on the establishment of a management program assuring that systems are regularly inspected and maintained. And trained and certified system operators will ensure that systems function effectively. While decentralized wastewater technologies work best for rural communities, a centralized management network to oversee them provides the most effective management and the best implementation for rural areas. The centralized management can be provided on a community, county or multiple county area.

In summary, establishment of wastewater infrastructure in rural areas should include a systematic evaluation of all options, beginning with consideration of on-site systems, cluster systems and finally, the centralized treatment option. When community leaders in rural North Carolina begin reviewing their wastewater management options, they should put decentralized wastewater systems at the top of their list to ensure public health and environmental protection, lower installation costs and the flexibility to plan for future growth.

Choices for Communities:

Wastewater Management Options for Rural Areas

A New Long-Term Strategy is Needed

Many rural communities lack a wastewater management infrastructure that can effectively protect public health, environmental quality and add value to current living conditions, let alone accommodate future housing needs and facilitate sound growth. Even when industries move into rural communities, the economic benefits resulting from creation of direct jobs and secondary service jobs are frequently lost due to leapfrogging of the population into nearby urban centers. This occurs because many rural communities do not have a reliable wastewater management infrastructure, while nearby cities and towns have public sewers and wastewater treatment plants. Eventually, the additional wastewater load exceeds the treatment plant's capacity, a development moratorium is imposed, and the economic vitality of the area is threatened.

The Clean Water Act of 1972 provided federal money for planning, design and construction of public wastewater infrastructure. From 1972 to 1993, when the federal Construction Grant Program existed, North Carolina spent $1.2 billion in federal money and $300 million in state funds on wastewater infrastructure. Even with these expenditures, $3 billion in unmet water and wastewater infrastructure needs remain in North Carolina.

Expansion of sewers throughout rural areas (the centralized approach) is not an option because it is too costly (up to $500 million for one county in North Carolina). In a number of cases, the cost of the collection system alone accounts for 70 to 90% of the construction costs for a communitywide sewerage project (GAO, 1994). The expense of constructing an extensive communitywide collection pipe network becomes most costly in less densely developed rural communities. Hence, the centralized approach may be difficult and expensive for many rural communities to implement. Furthermore, increasingly stringent mandates to reduce nutrient contributions in nutrient-sensitive watersheds limit the utility of surface-water discharges that meet these standards.

Land-based systems are environmentally sound.

Therefore, a comprehensive strategy needs to be developed for the timely and cost-effective treatment of municipal wastewater, especially in rural areas. Rural areas face many real resource limitations and associated problems in meeting surface-water discharge requirements that will continue to increase over time. It is virtually impossible and generally impractical to expect rural communities to achieve these advanced discharge requirements with just one project over a short time period. Most existing surface-water discharge systems have been upgraded continually to meet stream discharge standards as resources and capabilities allowed. Such a phased or stepwise strategy for wastewater management that meets current and future requirements is even more essential for rural communities, especially if alternatives to surface-water discharge are implemented as the most cost-effective approach.

Wastewater Treatment Options

Wastewater can be treated and disposed of using either surface or subsurface land-based technologies or surface-water discharge systems. Land-based systems include land application systems that discharge on top of the ground (called nondischarge systems) and those that discharge underground into the soil (called subsurface disposal systems). Typically, surface-water discharge systems use mechanical devices to aerate the wastewater prior to disposing of it in a receiving stream or river.

Nondischarge systems are permitted through the N.C. Department of Environment and Natural Resources (DENR), Division of Water Quality. Local health departments permit subsurface disposal systems under the auspices of the Division of Environmental Health in DENR. Systems that discharge to surface waters are permitted through the National Pollutant Discharge Elimination System (NPDES) program administered through the Division of Water Quality in DENR.

Land-based systems are judged to be the most cost-effective and environmentally sound for rural communities under present and anticipated future conditions. Land-based systems require extensive planning and stepwise implementation depending on the area to be served. Communities must determine the most cost-effective balance between on-site and cluster or community systems when utilizing land-based technologies. Because of minimal environmental impacts on streams and rivers, the regulatory community prefers the land-based alternatives.

While alternative wastewater handling options such as these land-based technologies are recognized as viable options, the treatment strategies are new or not often recommended by some in the private sector. This underscores the need to develop an achievable and environmentally sound strategy for the long-term, timely and cost-effective treatment of municipal wastewater in rural areas.

Community Needs Assessment

The development of a comprehensive wastewater management plan is a community process that begins with an assessment of local needs. Most often, failing septic systems or the inability to develop additional residential facilities in the community trigger the examination of alternative wastewater management options. Communities' needs assessments frequently are conducted by individuals unfamiliar with land-based options. As a result, the first recommendation is to develop a treatment facility that discharges to surface water.

Community leaders must consider the many options that exist between the conventional septic system and the traditional surface-water discharge system. The first step in the development of a local wastewater infrastructure is a clear definition of the problem. Careful planning that includes a comprehensive needs assessment, a thorough review of available alternatives and evaluation of the economic aspects of each alternative are essential steps required in the process of generating, analyzing and selecting appropriate wastewater management infrastructure.

The community must determine which wastewater management infrastructure approach best meets its needs.

To begin the process of planning for a local wastewater management infrastructure, first the community must organize. This requires identifying local leaders and available talent. Once organized, community leaders must establish planning goals and identify issues relevant to wastewater management. Often these address public health and environmental quality, but also should include economic development and growth issues. Next comes data gathering. Here community leaders examine environmental factors such as soil resources, groundwater quantity and quality, surface water carrying capacities for handling additional wastewater loads and site conditions for individual or community systems. Then the community must examine the financial ability of residents to pay for design, construction and operation of wastewater infrastructure options.

Assessing local needs requires compilation of information on and inventory of current wastewater problems. Obvious signs of system failure must be documented, water use data compiled, and a service area defined. Often the soil resources in a community may be suited for a land-based system, but because of documented septic system failure community leaders assume that soils cannot support this approach. The process of generating and analyzing alternatives begins by examining the potential to improve individual lots by targeting advanced designs of on-site systems to problem sites with failing septic systems. Then the process proceeds to evaluating the feasibility of a combination of individual on-site systems and small cluster land-based systems. Finally, the merits of providing a communitywide wastewater collection and treatment system should be assessed. All too often land-based options are ignored and decision makers are guided to surface-water discharge options as the preferred choice.

All too often the first options are ignored and decision makers are guided to the last option as the preferred choice.

Ultimately, community leaders must select a consultant to assist with the design of a program. The more information the community provides about local needs and wants the better the guidance provided to the consultant. Community leaders must insist on a comprehensive review of alternatives that includes on-site treatment improvements, community cluster land-based treatment options and a communitywide collection system. By insisting that the consultant provide a system that will meet the needs of the community, leaders can assure that the best interests of all residents are served.

Community Options for Wastewater Treatment

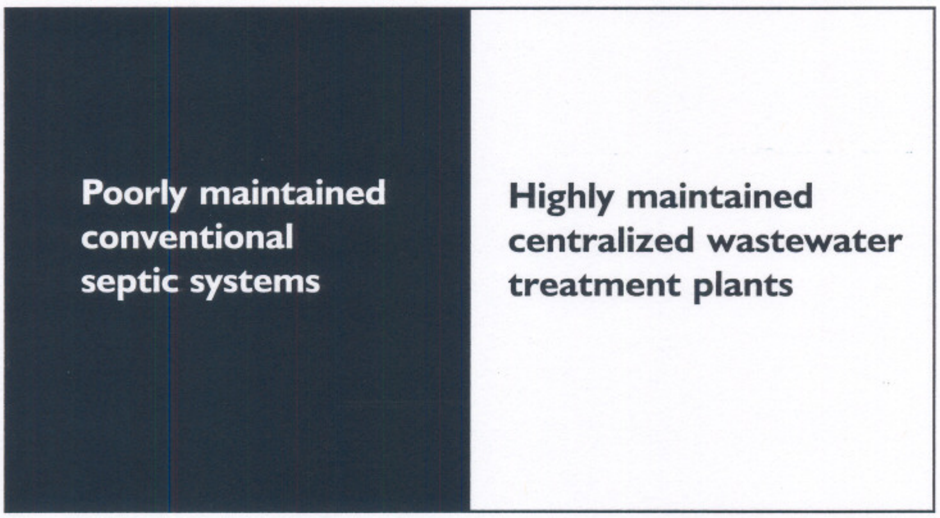
In the past, most communities had only two options to consider for their wastewater management infrastructure:

- ❑ Continue using poorly maintained traditional septic systems, or
- ❑ Install an extensive pipe network that collects wastewater to a centralized, highly maintained wastewater treatment plant.

Wastewater Management Infrastructure Choices

Historically, septic systems have not been maintained and over time enough of them have failed in a community to provide justification for construction of sewers and a wastewater treatment plant. Therefore, traditional septic systems came to be viewed as a temporary solution until the big pipe connected to a treatment plant came. Alternative, more advanced on-site septic systems, cluster systems and other land-based treatment techniques such as spray irrigation of wastewater were not considered to be mainstream options that communities could depend on. Consequently, the wastewater infrastructure choices for communities boiled down to two extremes — poorly maintained conventional septic systems on the one hand and highly maintained centralized treatment plants on the other — with no options in between. (See Figure 1, below.)

Figure 1. There are more options than the two extremes.



Centralized systems are sometimes called the "big pipe" or "sewer the country" approach. They involve installing an extensive network of large gravity sewer pipes throughout a community to collect the wastewater from homes and bring it to a central treatment plant followed by disposal in a stream or body of surface water.

Centralized sewerage systems have been the standard approach used since passage of the federal Clean Water Act Amendments in 1972. This law made significant funds available to many communities to pay substantial costs associated with wastewater collection and treatment. Further financial assistance was provided through the state legislature, while the remaining costs for infrastructure was provided by local government. For many communities in North Carolina, this combination of federal, state and local funding provided the impetus to develop a wastewater utility where none had existed. As a result of these funding sources, traditionally, rural communities have viewed centralized systems as a desirable end goal for their wastewater handling needs.

However, construction costs for centralized systems can be very high, and in some cases exceed the value of the community when a substantial combination of federal, state and local funding grants are not available. Often the collection network can account for 70 to 90% of the total construction cost, particularly if the community includes less densely developed areas.

In the 1970s and '80s, when both state and federal governments provided substantial financial grants to communities, often the government was paying 75 to 92.5% of the construction costs for the centralized collection network and the wastewater treatment plant. Communities that were fortunate to get these grants often would install a more expensive infrastructure than they could afford. Today, however, the federal Construction Grants Program no longer exists and communities must bear the full cost of establishing and maintaining their wastewater management infrastructure.

Both the decentralized and centralized approaches are equally viable and dependable as a community's wastewater management infrastructure.

Alternative Approaches

Yet, there are alternatives to the centralized approach of establishing a wastewater management infrastructure. Conventional septic systems are dependable options where soil conditions are favorable and the systems are properly maintained. More advanced on-site systems (sand filters, peat filters, pressure distribution systems, drip irrigation systems, disinfection systems) can be used over a much broader range of site and soil conditions than the conventional septic systems. Cluster systems use small collection networks to bring wastewater from a limited number of homes (usually 5 to 100) to a common treatment and disposal area. Cluster systems utilize alternative collection networks such as small-diameter gravity sewers and pressure sewer systems that are less expensive to install than the large pipes used in the centralized approach. Wastewater from a cluster system is pretreated and discharged either into a communal subsurface drainfield or into a land application system that uses irrigation.

Frequently, a community might be served by a combination of cluster systems in the more densely populated areas, or areas with less suited soil conditions, and on-site systems where soil conditions are conducive to their use. Advanced on-site systems, including cluster systems that serve multiple homes, have collectively been termed "decentralized wastewater treatment systems."

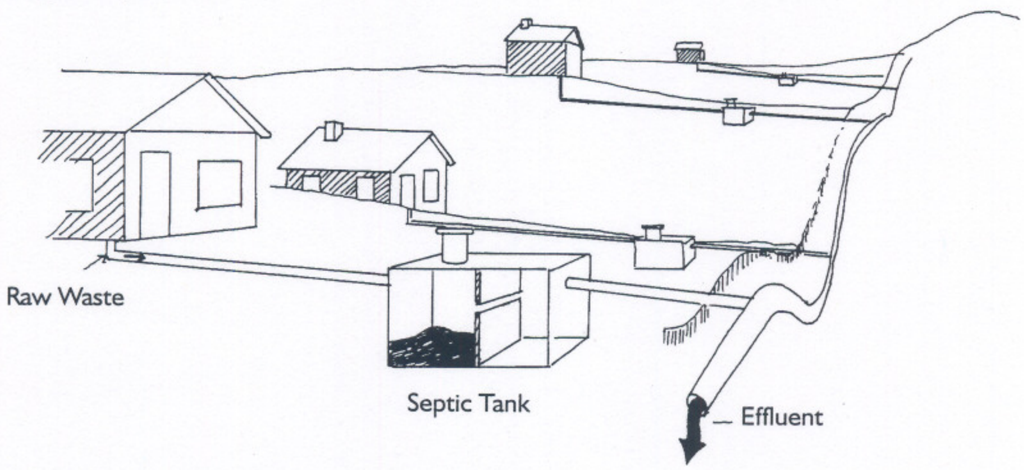
The viability of the decentralized approach depends on the establishment of an appropriate management program assuring that these technologies are properly operated and maintained. Trained and certified professional system operators are required to keep these systems functioning effectively. Regular inspections and maintenance must be required. Once a management program is in place, decentralized options become just as reliable and dependable as the centralized techniques. However, without adequate management, these technologies are doomed to failure just as the large centralized systems would be doomed to fail if they were not maintained.

Wastewater Collection Technologies

Most sewer systems in large cities have the traditional collection network of large-diameter pipes that collect wastewater from homes and transport it by force of gravity to a wastewater treatment plant. Gravity sewers, as the name suggests, convey wastewater by using the natural slope of the land. However, lift stations are needed when the slope of the land requires lifting the wastewater to a higher elevation. Another thing to consider with gravity sewers is that lines must be laid so that a minimum scouring velocity is maintained to move solids through the line. This can result in substantial excavation costs to install sewers deep enough to function via gravity flow. Also, large diameter pipe must be used, drastically increasing construction costs.

Yet, there are a number of alternative wastewater collection networks that can be used in many situations. A new adaptation to gravity collection sewers is small-diameter gravity sewers (see Figure 2 below), sometimes called effluent sewers. These systems include a septic tank at each home to remove the large solids. Smaller diameter wastewater collection pipes can be used since only liquid effluent flows through the collection network. Since this system utilizes smaller pipes that can be installed nearly on grade, the construction costs are much less than traditional gravity sewers. Periodic removal of accumulated solids in septic tanks is required as part of operation and maintenance.

Figure 2. Small diameter gravity sewers

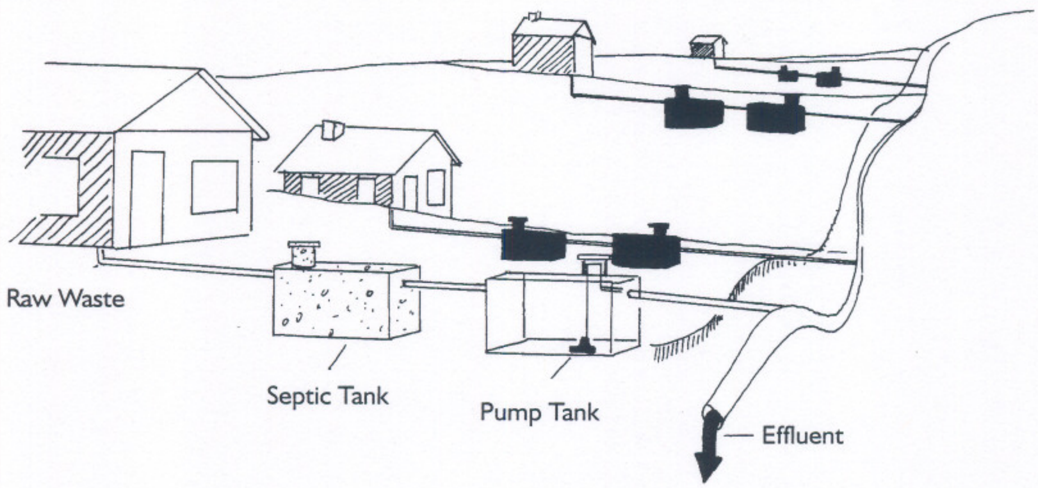


Alternative wastewater collection networks are less expensive to install than traditional gravity sewers.

Other collection options include small-diameter pressure sewers. One type is called a septic tank effluent pump system (STEP) and another a grinder pump system. The STEP system uses gravity to convey wastewater from the house to the septic tank. Then the effluent flows to the pump vault, where the wastewater is pumped under pressure to the treatment system or to other gravity lines. Figure 3 (next page) illustrates a typical STEP system. The grinder pump system like the STEP system uses gravity to convey wastewater from the house to the holding tank. A pump inside the tank grinds and shreds solid particles in the wastewater as it pumps. Then the wastewater is pumped under pressure to the treatment system or to a gravity line.

Installation costs for small-diameter pressure systems are usually relatively low for the same reasons as small-diameter gravity sewers. These pressure sewer systems follow contours and this results in lower costs. However, there

Figure 3. Septic tank effluent pump (STEP) system



are potentially higher operation and maintenance costs associated with pressure sewer systems related to the use of mechanical equipment. Pressure sewer collection networks typically have fewer problems with inflow and infiltration than traditional gravity sewers. One potential problem, though, is that grease build up, other blockages in the pipes or electrical outages can cause a negative impact.

Wastewater Treatment and Disposal

Mechanical treatment processes include preliminary treatment, primary treatment, secondary treatment and tertiary treatment. The level of wastewater treatment, and hence removal of pollutants, that is provided by these processes increases from preliminary through tertiary processes. Some wastewater treatment plants can meet their surface-water discharge permit limits by providing a secondary level of treatment. However, other treatment plants in nutrient-sensitive watersheds and other environmentally sensitive areas must be designed to include more advanced (and expensive) treatment processes to meet surface-water discharge permit limits.

Land-based treatment and dispersal technologies include a variety of lagoons, fixed media filters, subsurface dispersal systems such as a large variety of advanced on-site systems, and surface dispersal systems that are sometimes called land application systems. Fixed media filters include sand filters, peat filters and other biofilters. Advanced on-site systems utilize subsurface dispersal of the wastewater and include the traditional gravity distribution technologies, pressure manifold distribution and pressure distribution, including low-pressure pipe and drip-irrigation technologies.

Figure 4 (next page) illustrates one of the advanced pressure distribution technologies — drip irrigation — that can be installed at a homesite or, alternatively, over a multi-acre site to provide effective treatment and dispersal of wastewater from a small community. Land application systems include slow-rate spray irrigation and rapid infiltration processes. These are accomplished by dispersing the wastewater on the ground. Both the subsurface and surface dispersal land-based technologies utilize natural physical, chemical and biological soil processes to treat the wastewater as it passes through the soil. Adequate land must be available at land-based treatment sites to accommodate future expansion as with any mechanical wastewater treatment system. However, planning for these needs is important since land-based treatment systems have a defined, finite capacity for growth without available additional land.

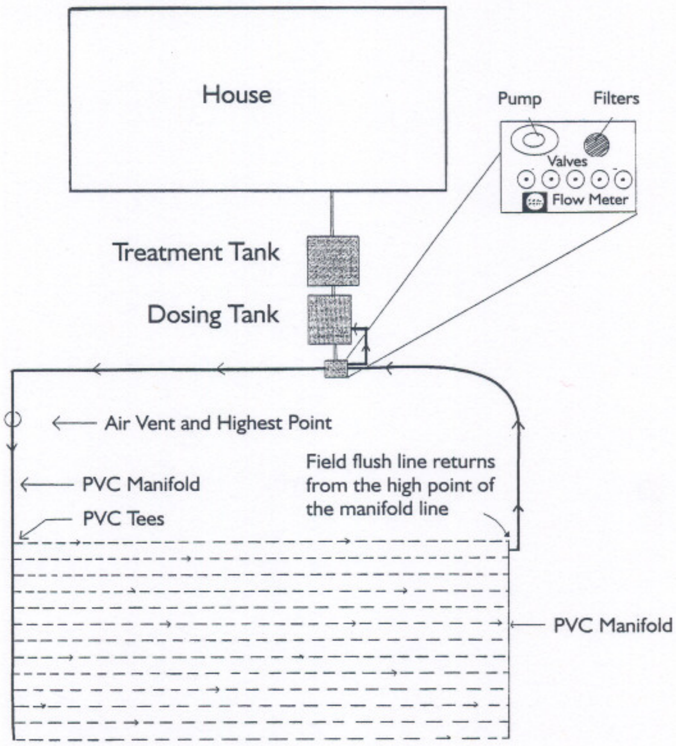


Figure 4. Drip irrigation technology for treatment and dispersal

Cost-Effectiveness of Land-Based Technologies

When considering wastewater management systems for small, rural communities, two problems emerge. The first, and often most costly of the system components, is the collection system. The second is the actual wastewater treatment and disposal system. Costs for wastewater infrastructure must be determined for both the capital and operation and maintenance components of total system cost. Often costs are described as a dollar per thousand gallons cost for operation and maintenance or as a dollar per gallon cost for initial capital.

The towns of Conway, Severin, Edenton and Garner; the Neuse River Water and Sewer Authority (NRWSA) and the Heavenly Mountain Community in Watauga County were selected to demonstrate the cost-effectiveness of land-based technologies. Each of the municipal systems is governed by its respective town council. The NRWSA facility is governed by a board of directors appointed by the Craven County commissioners. Heavenly Mountain is a private community, and the owner of the development is responsible for the operation of the system. Funding for construction of the publicly owned wastewater treatment facilities was provided by a combination of federal, state and local funds. The federal 201 program provided approximately 87.5% of the funds required for the design and construction of the municipal systems. Funding for the operation and maintenance of the public facilities is available through government entities, while private wastewater utilities are responsible for all aspects of the wastewater operation.

The costs for wastewater management vary dramatically from system to system (see table below). However, the cost of land-based systems is generally less than systems associated with stream discharge. The systems with the lowest construction and operation and maintenance costs are those that were constructed through funding provided by the Federal Construction Grants Program. The town of Garner and the NRWSA received some federal monies, but not the 92.5% funding allocated to others. As a result, the debt assumed by publicly owned facilities was higher than the debt assumed by other municipal systems. Consequently, the monthly operation and maintenance cost included debt retirement, adding dramatically to the cost of the system. The private utility operated at Heavenly Mountain was funded by private sources. The costs associated with this operation are high because the cost is amortized over 20 years. Also, the operation and maintenance cost for the wastewater treatment and dispersal operation require stringent treatment to a tertiary standard.

Land-based wastewater treatment systems are cost-effective.

Here are brief descriptions of the towns' wastewater management systems:

Severn — The town of Severn lies at the headwaters of the Chowan River Basin. In the mid-1970s, the Environmental Protection Agency declared the basin nutrient-sensitive and permitted discharges were required to achieve a high level of nutrient removal. Land application of the wastewater to an agricultural crop was selected as the desired wastewater management alternative. The system consists of a gravity collection system, pump stations to a treatment and storage lagoon and subsequent application to a small wastewater irrigation site.

Table 1 Costs for existing land-based technologies versus stream discharge**

facility	capacity MGD	capital cost $/Gallon	O&M cost $/1000 gallon	crop	hydraulic loading in/ac	maintenance intensity
Severn	0.05	3.7*	1.10	fescue	1.2	moderate
Conway	0.15	4.4*	1.64	hay/trees	1.2	high to low
Edenton	0.9	6.8*	0.67	plantation trees	0.9 to 1.2	low
Garner	1.2	3.5*	0.76	plantation trees/hay	0.7 to 1.1	high to low
NRWSA	0.35	10.28** (4.26)***	2.06 (0.99)	row crops/hay	0.7 to 1.5	very high
Heavenly Mtn.	0.015	13.3** (9.33)***	4.01	forest	0.6	low

* Existing collection systems used

**New collection systems built

***Costs for treatment/dispersal components exclusive of collection network expenditures

****Capital and operation and maintenance costs included

Conway — The town of Conway is located in the Chowan River Basin. Land application by slow-rate spray irrigation was deemed the most cost-effective alternative for the town. Preapplication treatment is provided in a wastewater lagoon.

Edenton — The town lies at the mouth of the Chowan River, and the river's nutrient-sensitive classification forced examination of a variety of nutrient removal strategies. The community lagoon/spray irrigation option was deemed the most cost-effective.

Garner — The town is in the Neuse River Basin, and recently the basin was declared nutrient-sensitive. The town developed a slow-rate spray irrigation facility in the late 1980s because the classification of Swift Creek required substantial removal of oxygen-demanding materials. The community lagoon/spray irrigation system was selected the most cost-effective wastewater management option for the town.

Neuse River Water and Sewer Authority — This facility serves customers in the lower Neuse River Basin. The irrigation operations take place on private farm land. The system developed for NRWSA included both a wastewater collection system and a wastewater treatment system consisting of lagoons and a spray irrigation field. The costs in Table 1(page 13) reflect the total cost of the system and the cost for the lagoon/land application portion.

Heavenly Mountain — Wastewater treatment requirements were stringent because the development is surrounded by trout streams, and discharges of wastewater are tightly controlled. The use of extensive pretreatment followed by surface drip irrigation was the selected wastewater management alternative. The community obtained a used "package plant" capable of achieving a secondary level of wastewater treatment. The total cost for this system and the cost for the treatment and drip irrigation component only are presented in Table 1(page 13).

Comparison of the Centralized and Decentralized Approaches

Few cases exist where the decentralized approach to wastewater management has been compared evenly with the centralized approach. However, recently Congress asked the U.S. Environmental Protection Agency to evaluate the capabilities and cost effectiveness of the decentralized approach to wastewater management and to identify barriers and solutions to implementation of this approach. According to the *EPA Response to Congress* (EPA, 1997), decentralized systems:

- ❑ protect public health and the environment
- ❑ are appropriate for low density communities
- ❑ are appropriate for varying site conditions
- ❑ provide additional benefits for ecologically sensitive areas, and
- ❑ can provide significant cost savings while recharging local aquifers and providing other water reuse opportunities close to the points of wastewater generation.

In its assessment, the EPA developed a detailed analysis of costs in a hypothetical rural community (Figure 5 below), comparing the decentralized approach with the traditional centralized approach to establish a wastewater management infrastructure. The rural community was assumed to have 450 people living in 135 homes. These homes were located on one-acre lots or larger that were serviced by conventional septic systems. It was assumed that 50% of the septic systems (67 systems) were failing. Three wastewater management options considered for the rural community were installation and long-term operation and maintenance of:

(1) a centralized system

(2) cluster systems and

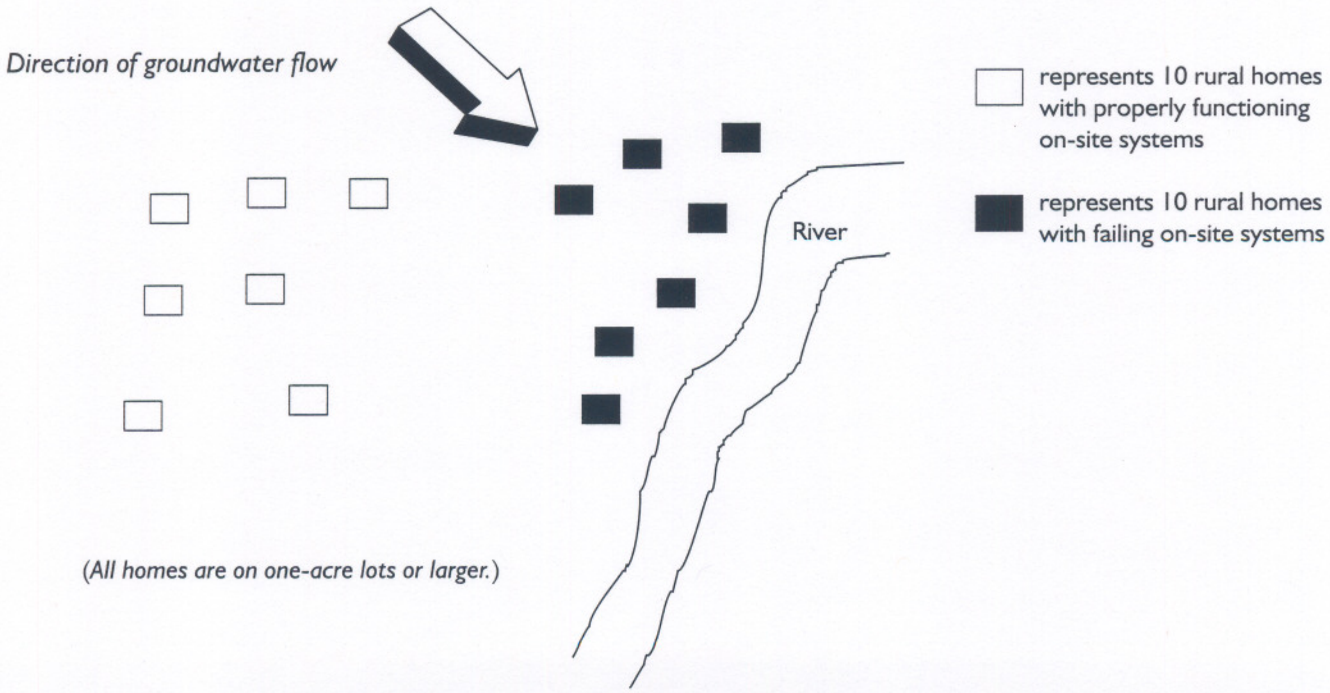
(3) managed on-site systems

Expenditures included the capital costs necessary to install the systems and annual costs to operate and maintain them. Capital costs were annualized over 30 years (the life of the system) for each technology using a discount rate of 7%. Costs are presented in 1995 dollars in Table 2 on page 16.

This analysis revealed that the decentralized approach (using either managed on-site systems or cluster systems) frequently will be a more cost-effective wastewater management option than centralized sewering for rural communities that are not densely developed (Table 2 on page 16). These cost estimates included establishing a management program to provide long-term maintenance of each technology. The most cost-effective option for meeting performance goals is using new on-site systems of advanced designs to replace failing conventional septic systems. Using cluster systems with alternative

The decentralized approach to wastewater management frequently is more cost-effective for rural communities than centralized sewering.

Figure 5. Base map of EPA hypothetical rural community (adapted from EPA, 1997)



collection to replace failing septic systems is not significantly more expensive. If soils were unsuitable for on-site systems, the cluster alternative would be the best choice. As the distance between homes in the rural area increases, however, cluster system collection costs increase. Compared to on-site or cluster system options, centralized collection and treatment is not cost-effective in this case.

Table 2 Summary of hypothetical EPA rural community technology costs

Technology option	Total capital cost (1995 $)	Annual O&M* cost (1995 $)	Total annual cost (annualized capital plus O&M* – 1995 $)
Centralized systems	$2,321,840 - $3,750,530	$29,740 - $40,260	$216,850 - $342,500
Alternative SDGS** collection and small cluster systems	$598,100	$7,290	$55,500
On-site systems	$510,000	$13,400	$54,500

Note: The rural community consists of 450 people in 135 homes.
*O&M means operation and maintenance
**SDGS stands for small-diameter gravity sewers
(Adapted from EPA, 1997)

Communitywide management of on-site systems rarely has been utilized in the United States. The closest North Carolina example exists in the northeastern part of the state where the Pasquotank-Perquimans-Camden-Chowan counties District Health Department in 1992 established one of the first communitywide management entities for managing on-site systems. The purpose was to facilitate use of alternative on-site technologies and associated communitywide drainage networks that had been shown to fail if not maintained correctly. Since 1992 more than 1,000 advanced on-site systems have been included in the management entity. The district management entity inspects these systems once a year for a fee of $50 to ensure their continued performance, and each county contributes to the operational costs of the management entity. Landowners are required to upgrade any failing system and to correct any improperly functioning drainage network at their cost. The management entity monitors only the alternative on-site technologies not conventional septic systems in the community.

Summary

The viability of waste treatment technologies will vary substantially depending on a community's density of development, financial resources, site conditions and surface-water discharge requirements throughout the watershed.

Infrastructure limitations, however, are rapidly changing due to the realization that land-based treatment technologies are frequently the most cost-effective and environmentally protective methods for handling municipal wastewater in rural and small communities. Today a multitude of infrastructure choices that range from centralized to decentralized and all options in between are available to serve communities' needs (Figure 6 next page).

These include a variety of on-site treatment systems, small-scale community collection and treatment systems, and large-scale municipal wastewater collection and treatment systems. These options provide effective management of a community's wastewater regardless of the density of development in the area. In fact, frequently the best approach in a given community will be a combination of centralized and decentralized systems. The location of each will depend not only on the density of development, but also on plans for locating future growth, cost issues and water quality and quantity concerns regarding nutrient-sensitive watersheds.

Conventional septic systems	Small scale alternative, on-site and cluster systems	Central treatment plant

- ❑ Low to very high development density
- ❑ Rural to urban landscape
- ❑ Moderate costs
- ❑ Moderately complex technology
- ❑ Regular O&M review and adjustment
- ❑ Assessment of environmental impacts
- ❑ System technology upgraded to meet emerging community and environmental needs

Figure 6. A communitywide management program can facilitate use of the complete range of infrastructure choices, rather than just the two extremes.

Land-based options such as on-site systems, cluster systems, and land application systems are frequently a more environmentally friendly approach where surface waters are particularly valuable or vulnerable to contamination.

New funding initiatives are being developed in North Carolina to establish a dependable wastewater infrastructure in rural communities that will sustain growth and protect the environment. As these initiatives come to fruition, the available funding should be utilized to provide economically sound, dependable solutions to the largest number of communities possible. More rural communities will be positively impacted if land-based wastewater treatment options are embraced to meet future community needs.

Citations:

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